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Studies on a Catena in Coimbatore District
II. Physical Properties*

by

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Synopsis: This second paper on the studies of a catena in Coimbatore district presents texture and physical constants of twenty five soil samples drawn from eight profiles of the catena. Correlations between the mechanical fractions and physical constants are not affected by the depth and topography. (The part I was published in June 1965 issue).

Introduction: In the previous paper, the physical setting of the catena and morphological features of eight profiles dug in the catena have been presented. The physical properties and their inter-relationships are discussed in the present paper. The physical properties such as texture, true and apparent densities, maximum water-holding capacity, pore space and volume expansion on swelling show relationship not only to the chemical, physico-chemical and bio-chemical properties of soils but also among themselves. Such relationships are useful in characterising soils. When the relationship is highly significant, the soil property may be used to predict other properties.

Review of Literature: Of the different mechanical fractions, clay has been found to be very highly influencing many of the soil properties. Briggs and Shantz (1912), Alway and Rost (1916), Alway and Russel (1916), Smith (1917) and Joachim and Kandiah (1947), working on different types of soils, have found out that clay is highly correlated with physical properties and moisture constants of the soils. The coarser particles generally tend to decrease the values of moisture constants. Presscott and Poole (1934), Wilcox (1939) and Wilcox and Spilsbury (1941) have recorded similar observations from their study.

Single value constants, namely, true and apparent densities, maximum water-holding capacity, pore space, and volume expansion on swelling have been found to be highly inter-related. Close correlations among these constants were observed by workers like Briggs and Shantz (1912) and Capalungan and Murphy (1930).

Some of the soil properties like texture form the basic soil characters and other properties depend on these basic soil characters. The dependent properties can be predicted with reasonable accuracy from the basic

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characters using statistical methods. Many investigations on this aspect taking texture as the basic characters have been carried out by Briggs and Shantz (1912), Alway and Rost (1916), Smith (1917) and many others. Recently work in Indian soils on the relationship of texture and soil moisture constants have been undertaken by Subba Rao (1960), Kandaswamy (1961), Venkataramanan (1962) and Premanathan (1963), who have also observed close relationship between texture and soil moisture constants. Another interesting observation made by these workers is that the relationship between soil properties are close inspite of the fact that soils studied are of different types.

In the present study an attempt is made to investigate these relationship with reference to a catena and to observe whether there is any influence of the depth and topography on these relationships.

Materials and Methods: Twenty five soil samples drawn from the horizons of eight profiles of the catena have been analysed for mechanical fractions by adopting the Robinson Pipette method. Detritus, retained on the 2 mm sieve, was weighed directly and accounted. Determinations of physical constants, namely, true and apparent densities, maximum water-holding capacity, pore space and volume expansion on swelling were made using brass cups. Table I gives the percentages of mechanical fractions. The mechnical analysis data were recalculated on the basis of whole soil material including detritus. The recalculated values are shown in Table II. The physical constants are tabulated in Table III. Their relationships among themselves and to the mechanical fractions were statistically worked out and the results are presented in Table IV.

TABLE 1

Mechanical Fractions

Depth in inch	Clay per cent	Silt per cent	Fine sand per cent	Coarse sand per cent	Acid solubles per cent	Total
		Hill - top Profile				
0—5	6·00	1·73	35·48	57·17	...	...
5—11	9·81	3·71	34·60	51·68	0·20	100·0
below 11	5·79	2·97	28·35	64·22	...	...
		II Profile				
0—9	10·84	3·46	37·85	48·45	...	...
9—23	18·00	3·72	34·77	48·36	0·15	100·0
23—33	22·22	6·02	31·38	37·10	3·28	100·0
below 33	13·16	7·97	22·61	41·77	14·49	100·0

TABLE I (*Contd.*)

Depth in inch	Clay per cent	Silt per cent	Fine sand per cent	Coarse sand per cent	Acid solubles per cent	Total
	III Profile					
0— 4	15·02	4·11	38·19	44·62	...	...
4—17	25·61	4·68	30·77	40·12	...	...
17—24	28·50	5·36	27·66	32·72	5·76	100·0
24—35	30·10	5·78	25·23	29·73	9·16	100·0
below 35	7·78	12·28	27·89	36·75	15·30	100·0
	IV Profile					
0— 9	19·53	3·45	30·80	46·34	...	...
9—39	17·24	8·21	24·08	34·21	16·26	100·0
below 39	6·34	7·68	15·49	68·31	7·23	100·0
	V Profile					
0— 4	13·37	1·39	29·51	55·20	0·53	100·0
4—20	18·01	3·31	19·22	51·20	8·26	100·0
	VI Profile					
0— 3	6·08	0·60	31·85	61·14	0·33	100·0
3— 7	15·42	2·29	26·67	54·94	0·68	100·0
	VII Profile					
0— 6	7·82	6·58	30·88	54·15	0·57	100·0
6—11	11·35	4·40	45·78	39·83	...	...
below 11	13·20	3·33	22·72	54·54	6·21	100·0
	Valley Profile					
0—11	10·80	2·28	30·11	56·32	0·49	100·0
11—19	16·17	1·69	26·00	55·18	0·96	100·0
19—25	18·39	4·74	22·34	55·31	...	...

TABLE II

Mechanical fractions on the basis of whole soil material including detritus

Depth in inch	Detritus per cent	Clay per cent	Silt per cent	Fine sand per cent	Coarse sand per cent	Acid soluble per cent
	Hill-top Profile					
0— 5	22·33	4·66	1·34	27·52	44·40	...
5—11	57·73	4·15	1·57	14·63	21·85	0·08
below 11	66·68	1·93	0·99	9·45	21·40	...

TABLE II (*Contd.*)

Depth in inch	Detritus per cent	Clay per cent	Silt per cent	Fine sand per cent	Coarse sand per cen	Acid soluble per cent
	II Profile					
0— 9	10·51	9·70	3·10	33·87	44·36	...
9—23	7·00	16·74	3·46	32·34	40·32	0·14
23—33	72·49	6·11	1·66	8·63	10·21	0·90
below 33	89·17	1·43	0·86	2·45	4·52	1·57
	III Profile					
0— 4	8·82	13·70	3·75	34·82	40·68	...
4—17	11·28	22·72	4·15	27·30	35·59	...
17—24	70·32	8·46	1·59	8·21	9·71	1·71
24—35	51·77	14·52	2·79	12·17	14·34	4·42
below 35	45·99	4·20	6·63	15·06	19·85	8·26
	IV Profile					
0— 9	2·46	19·05	3·37	30·04	45·20	...
9—39	59·45	6·99	3·33	9·76	13·87	6·59
below 39	60·00	2·54	3·05	6·20	25·32	2·89
	V Profile					
0— 4	30·48	9·29	0·97	20·52	38·38	0·37
4—20	47·96	9·37	1·72	10·00	26·64	4·30
	VI Profile					
0— 3	13·37	5·27	0·52	27·59	52·97	0·29
3— 7	5·90	14·51	2·15	25·10	51·90	0·64
	VII Profile					
0— 6	13·83	6·74	5·67	26·61	46·66	0·49
6—11	17·26	9·39	3·64	37·88	32·96	...
below 11	84·85	2·00	0·50	3·44	8·26	0·94
	Valley Profile					
0—11	5·77	10·18	2·15	28·37	53·07	0·46
11—19	4·07	15·51	1·62	24·94	52·93	0·92
19—25	18·31	15·02	3·87	18·25	45·18	...

TABLE III

Physical Constants

Depth	Apparent specific gravity	True specific gravity	Pore space per cent	Maximum water-holding capacity per cent	Volume expansion on wetting per cent
	Hill-top Profile				
0—5	1·55	2·26	36·37	25·02	6·37
5—11	1·41	2·76	40·40	31·70	10·04
	II Profile				
0—9	1·43	2·24	43·01	32·47	11·15
9—23	1·27	2·10	47·90	42·63	15·52
23—33	1·23	2·20	51·62	51·22	23·34
	III Profile				
0—4	1·40	2·07	43·22	35·91	18·06
4—17	1·31	2·15	51·68	47·16	23·83
17—24	1·25	2·22	55·80	53·07	24·41
24—35	1·25	1·99	50·42	53·76	28·73
below 35	1·42	2·14	45·30	26·65	9·76
	IV Profile				
0—9	1·29	2·12	48·82	44·23	18·67
9—39	1·25	2·16	53·64	40·76	14·04
below 39	1·40	2·19	38·32	28·59	4·42
	V Profile				
0—4	1·54	2·30	40·56	30·13	10·23
4—20	1·36	2·14	45·87	31·19	10·58
	VI Profile				
0—3	1·56	3·01	36·37	25·16	6·53
3—7	1·34	2·17	45·30	37·46	11·42
	VII Profile				
0—6	1·52	2·36	40·35	29·17	8·01
6—11	1·39	2·29	44·13	35·06	11·73
	VIII Profile				
0—11	1·40	2·40	46·78	37·31	10·23
11—19	1·42	2·24	47·90	42·40	23·81
19—25	1·34	2·10	48·70	43·25	21·53

TABLE IV

Simple correlations among mechanical fractions and physical constants

	Clay	Silt	Fine sand	Coarse sand	Apparent specific gravity	True specific gravity	Pore space	Maximum water-holding capacity	Volume expansion on swelling
Clay	...	...	–0·1904	–0·7496***	–0·8208***	–0·6120**	0·8553***	0·9294***	0·9035***
Silt		...	–0·5066*	...	–0·3711	–0·3815	0·3008	...	...
Fine sand					...	–0·3202	–0·2010	...	...
Coarse sand					0·7030***	0·2180	–0·8433***	–0·6476***	–0·6252**
Apparent specific gravity						0·5637**	–0·8798***	–0·8519***	–0·6963***
True specific gravity						...	–0·5408**	–0·4762*	–0·4806*
Pore space							...	0·9915***	0·7998***
Maximum water-holding capacity									0·9258***
Volume expansion on swelling									...

Results and Discussion: *Texture:* Textural analysis shows a gradation with depth and topography. The texture of the hill-top profile is sandy, but it changes to sandy loam in the upper slope members (III and IV profiles) to become again sandy in the lower slope members and in the valley profile.

The clay distribution in the profiles indicates a definite pattern of variation with depth. The clay contents of the hill-top, II and III profiles increase with depth to decrease again in the horizon of parent material. The clay content of IV profile decreases from the top horizon downward.

Since a gully has developed in between the IV and V profiles, it may be assumed that top horizons of the original IV profile would have been washed away by erosion. The V profile reveals clear symptom of truncation. Hence, the clay distribution pattern of this profile does not conform to the upper slope members. In the case of VI, VII and valley profiles, the amounts of clay increase with the depth till the parent material is reached. The clay distribution patterns show no stratification and are normal. Therefore, the clay distribution establishes the uniformity of the parent material in all the profiles.

The contents of detritus of the members of the catena are high. In all the cases except VI profile, the quantity of detritus increases generally with the depth, whereas in the case of VI profile, there is a band of quartz pebbles. The high content of detritus influences the type of soil structure and the pattern of drainage of the profiles. It also affects the clay migration within and away from the profiles. Drainage water is generally found to carry a large quantity of clay-sized particles. Detritus forms an important part of the profile body in the catena. Therefore, it was thought that recalculation of mechanical fractions on the basis of whole soil material including detritus might throw more light on the clay migration.

The recalculated figures present a different picture of clay distribution in the profiles. In the hill-top profile, there is only a slight decrease in the second horizon showing no vertical migration of clay from the top horizon. The clay accumulative layer occurs at the second horizon in the II profile. In the case of III profile, the content of clay increases in the second horizon and drops in third to rise again in the fourth horizon. The IV, VI and valley profiles indicate the same kind of trend in clay distribution similar to the previous figures. In the case of V profile, there is no vertical migration of clay, whereas there is clay accumulation in the second horizon of the VII profile.

Although a different picture is observed with the recalculated figures, it is difficult to point out exclusive usefulness of such recalculation. Both set of figures appear to suggest that there is no redeposition of soil material in the lower members of the catena and even in the valley profiles. The clay should probably have been carried away from the catena itself in the drainage waters.

Inter-relationship between mechanical fractions and physical constants: The salient features of statistical analysis and correlations worked out to test the relative dependence of the physical constants on the mechanical fractions and also to assess the inter-relationship of the physical constants are as follows. The correlation coefficients in most cases were highly significant even at 0.1 per cent level. The clay is positively correlated with pore space, maximum water-holding capacity, and volume expansion on swelling, but negatively correlated with apparent and true densities. The coarse sand is negatively correlated with pore space, maximum water-holding capacity and volume expansion on swelling and positively correlated with the apparent density. It is not correlated with true density.

Depth and topography do not seem to materially alter the relationships between mechanical fractions and physical constants. This may be due to a similar genetic make up of all the profiles of the catena

The correlations point to the dominating influence of mechanical fractions on the physical properties of soil. Since the correlation coefficients are at the level of very high significance, it could be concluded that the physical constants are functions of the same set of basic characters. Therefore, the relationship can be put as follows:

$$\text{Physical property} = f\ (\text{texture}) \qquad (1)$$

The present study allows us to conclude that the basic character is texture. However, the relationship to the texture does not attain the level of unity, showing that the correlation is not complete. There may be other interfering factors such as organic matter, salt concentration and exchangeable cations to influence the physical properties of soil. Including these factors the equation (1) can be written as follows:

$$\text{Physical property} = f\ (\text{texture, organic matter, salt concentration, exchangeable cations}) \qquad (2)$$

To solve this equation further studies are required.

Summary: In this second paper on the studies of a catena in Coimbatore district, texture and physical constants of twentyfive soil samples drawn from eight profiles of the catena are presented and discussed. Correlations between the mechanical fractions and physical constants were statistically worked out. The clay is positively correlated with pore space, maximum water-holding capacity and volume expansion on swelling, and negatively correlated with apparent and true densities. The coarse sand is negatively correlated to pore space, maximum water-holding capacity and volume expansion on swelling and positively correlated with the apparent density. It is not correlated with true density. The correlations are not affected by the depth and topography.

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